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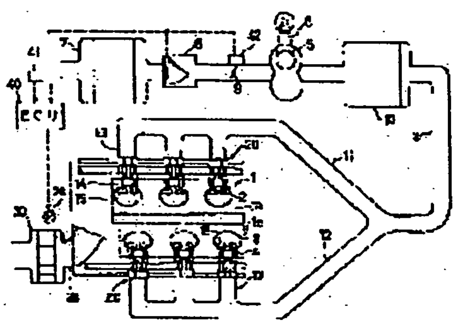
(71)Applicant : MAZDA MOTOR CORP
(72)Inventor : HITOMI MITSUO
IWATA NORIYUKI

(54) INTAKE AIR QUANTITY CONTROLLER OF ENGINE

(57)Abstract:
PURPOSE: To rapidly vary an air-fuel ratio of an engine with high responsiveness without generating any large torque shock.
CONSTITUTION: A closing timing of an intake valve 15 is varied by a valve timing varying means 20. A target air-fuel ratio becomes larger than a theoretical air-fuel ratio in a low load range, by an ECU 40, and then the air-fuel ratio of an engine is controlled as the target air-fuel ratio becomes an air-fuel ratio less than the theoretical air-fuel ratio in a high load range. In addition, an intake air quantity is decreased at the time of transferring from the low load range to the high load range, by increasing delay angle from the piston bottom dead point of an intake valve closing timing, and the intake air quantity is increased by decreasing the delay angle from the piston bottom dead point of the intake valve closing timing at the time of transferring from the high load range to the low load range so as to control operation of the valve timing varying means 20.



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(71)出願人　000003137
マツダ株式会社
広島県安芸郡府中町新地3番1号

(72)発明者　人見　光夫
広島県安芸郡府中町新地3番1号　マツダ株式会社内

(72)発明者　岩田　典之
広島県安芸郡府中町新地3番1号　マツダ株式会社内

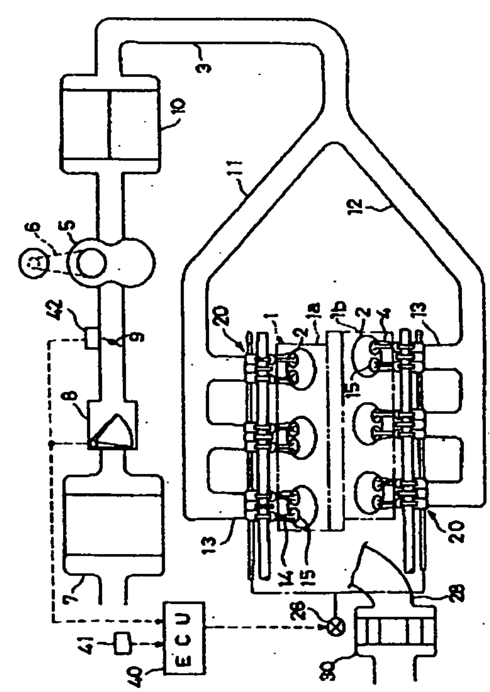
(74)代理人　弁理士　小谷　悦司　（外3名）

(54)【発明の名称】エンジンの吸入空気量制御装置

(57)【要約】

【目的】　大きなトルクショックを発生させることなく、エンジンの空燃比を高い応答性で迅速に変化させる。

【構成】　バルブタイミング可変手段20は、吸気弁15の閉時期を変化させる。ECU40は、低負荷領域では目標空燃比を理論空燃比よりも大きい空燃比とし、高負荷領域では目標空燃比を理論空燃比以下の空燃比としてエンジンの空燃比制御を行うとともに、低負荷領域から高負荷領域への移行時には吸気弁閉時期のピストン下死点からの遅れ角を増やして吸入空気量を減らし、高負荷領域から低負荷領域への移行時には吸気弁閉時期のピストン下死点からの遅れ角を減らして吸入空気量を増やすように上記バルブタイミング可変手段20の作動を制御する。



【特許請求の範囲】

【請求項1】 予め設定された第1の運転領域では目標空燃比を理論空燃比よりも大きい空燃比とし、上記第1の運転領域と異なる第2の運転領域では目標空燃比を理論空燃比以下の空燃比として実際の空燃比が制御されるエンジンにおいて、上記エンジンの吸気弁、排気弁の少なくとも一方の開弁期間を変化させる開弁期間可変手段と、上記第1の運転領域から第2の運転領域への移行時には吸入空気量を減らし、上記第2の運転領域から第1の運転領域への移行時には吸入空気量を増加させるように上記開弁期間可変手段を作動させる開弁期間制御手段とを備えたことを特徴とするエンジンの吸入空気量制御装置。

【請求項2】 請求項1記載のエンジンの吸入空気量制御装置において、上記開弁期間可変手段は、上記吸気弁の閉時期を変化させるものであり、上記開弁期間制御手段は、上記第1の運転領域から第2の運転領域への移行時には吸入空気量を減らし、上記第2の運転領域から第1の運転領域への移行時には吸入空気量を増加させるタイミングで上記吸気弁を閉弁させるように上記開弁期間可変手段を作動させるものであることを特徴とするエンジンの吸入空気量制御装置。

【請求項3】 請求項2記載のエンジンの吸入空気量制御装置において、過給機を備えるとともに、上記第1の運転領域をエンジン負荷が一定以下の低負荷領域とし、上記第2の運転領域を上記第1の運転領域よりもエンジン負荷が高い高負荷領域として、上記第2の運転領域内ではピストン下死点からの上記吸気弁の閉時期のずれ角を第1の運転領域内におけるピストン下死点からの上記吸気弁の閉時期のずれ角よりも大きな角度に保つように上記開弁期間可変手段を作動させるように上記開弁期間制御手段を構成したことを特徴とするエンジンの吸入空気量制御装置。

【請求項4】 請求項3記載のエンジンの吸入空気量制御装置において、上記開弁期間制御手段は、上記第1の運転領域から第2の運転領域への移行時にはピストン下死点からの上記吸気弁の閉時期の遅れ角を増やし、上記第2の運転領域から第1の運転領域への移行時にはピストン下死点からの上記吸気弁の閉時期の遅れ角を減らすように上記開弁期間可変手段を作動させるものであることを特徴とするエンジンの吸入空気量制御装置。

【請求項5】 請求項1～4のいずれかに記載のエンジンの吸入空気量制御装置において、上記第1の運転領域における目標空燃比が排気ガス中の窒素酸化物濃度が最大となる空燃比よりも高い空燃比であることを特徴とするエンジンの吸入空気量制御装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、運転状態に応じて空燃比が制御されるエンジンにおいて、その吸入空気量を制御するための装置に関するものである。

【0002】

【従来の技術】近年、エンジンの排気ガスにおける窒素酸化物（NOx）濃度の削減が大きな課題とされているが、このNOx濃度と実際の空燃比A／Fとの間には一般に図6に示すような関係があることが知られている。この関係によれば、空燃比A／Fが一定値（約16）の時にNOx濃度はピークを迎えるので、NOx濃度を下げるにはなるべく上記の空燃比を避けて運転制御すれば良いことになる。例えば、エンジンの運転状態の変化に応じて燃料リーンの燃焼状態（点A）から燃料リッチの燃焼状態（点B）に移行する場合には、空燃比A／Fを徐々に下げるのではなく点Aから点Bまで一気に下げ、空燃比A／F＝16付近は一瞬も使わないようにすることにより、NOx濃度の増大を避けることが可能である。逆に、点Bから点Aに移行する場合には、空燃比A／Fを一気にリーンにすればよい。

【0003】ところで、上記空燃比を制御する手段としては、吸入空気量を調節するのが一般的であるが、上記のように空燃比を素早く増減させるのに空気量変化にはどうしても遅れが生じて空燃比と点火時期等とにずれが生じ、これに伴って大きなトルクショックが生じる不都合がある。

【0004】そこで、特開平4－265437号公報では、目標空燃比をリーン側に切換える際、スロットル弁のバイパス通路を開いて吸入空気量を増加させることにより、実際の空燃比を素早く増加させるようにした装置が提案されている。

【0005】

【発明が解決しようとする課題】上記公報の装置において、スロットル弁やそのバイパス通路から各気筒の燃焼室内に至るまでの吸気通路は比較的長く、大きな容積を有している。従って、バイパス通路の開閉切換を行ってから実際に吸入空気量が増減するまでにはかなりの応答遅れがあり、適切なタイミングで空燃比を制御することが困難であるとともに、この応答遅れ期間における空燃比の変化が緩慢となってNOx濃度が高い空燃比を通ってしまう不都合がある。この不都合は、スロットル弁の開度調節で吸入空気量を増減する場合にも同様に生じる。

【0006】本発明は、このような事情に鑑み、燃料噴射量の急変によるトルクショックを避けながら、実際の空燃比を高い応答性で素早く変化させることができるエンジンの吸入空気量制御装置を提供することを目的とする。

【0007】

【課題を解決するための手段】上記課題を解決するための手段として、本発明は、予め設定された第1の運転領域では目標空燃比を理論空燃比よりも大きい空燃比とし、上記第1の運転領域と異なる第2の運転領域では目

標空燃比を理論空燃比以下の空燃比として実際の空燃比が制御されるエンジンにおいて、上記エンジンの吸気弁、排気弁の少なくとも一方の開弁期間を変化させる開弁期間可変手段と、上記第１の運転領域から第２の運転領域への移行時には吸入空気量を減らし、上記第２の運転領域から第１の運転領域への移行時には吸入空気量を増加させるように上記開弁期間可変手段を作動させる開弁期間制御手段とを備えたものである（請求項１）。

【０００８】より具体的に、上記開弁期間可変手段は、上記吸気弁の閉時期を変化させるものが、上記開弁期間制御手段は、上記第１の運転領域から第２の運転領域への移行時には吸入空気量を減らし、上記第２の運転領域から第１の運転領域への移行時には吸入空気量を増加させるタイミングで上記吸気弁を閉弁させるように上記開弁期間可変手段を作動させるものが、好適である（請求項２）。

【０００９】さらに、過給機を備えるとともに、上記第１の運転領域をエンジン負荷が一定以下の低負荷領域とし、上記第２の運転領域を上記第１の運転領域よりもエンジン負荷が高い高負荷領域として、上記第２の運転領域内ではピストン下死点からの上記吸気弁の閉時期のずれ角を第１の運転領域内におけるピストン下死点からの上記吸気弁の閉時期のずれ角よりも大きな角度に保つように上記開弁期間可変手段を作動させるように上記開弁期間制御手段を構成することにより、後述のようなより優れた効果が得られる（請求項３）。

【００１０】ここで、上記開弁期間制御手段は、上記第１の運転領域から第２の運転領域への移行時にはピストン下死点からの上記吸気弁の閉時期の遅れ角を増やし、上記第２の運転領域から第１の運転領域への移行時にはピストン下死点からの上記吸気弁の閉時期の遅れ角を減らすように上記開弁期間可変手段を作動させるものであることが、より好ましい（請求項４）。

【００１１】以上の各装置は、上記第１の運転領域における目標空燃比が排気ガス中の窒素酸化物濃度が最大となる空燃比よりも高い空燃比である場合に特に有効である（請求項５）。

【００１２】

【作用】上記装置によれば、第１の運転領域から第２の運転領域への移行時には吸入空気量を減らし、上記第２の運転領域から第１の運転領域への移行時には吸入空気量を増加させることにより、空燃比を素早く切換えることが可能となる。つまり、この吸入空気量の増減は、燃焼室を開閉する吸気弁や排気弁の開弁期間の制御によって行われるため、燃焼室から離れたスロットル弁やそのバイパス通路の開閉によって吸入空気量を制御する場合に比べ、吸入空気量及び空燃比は瞬時に変化することとなり、制御の応答性が大幅に高まる。

【００１３】より具体的に、請求項２記載の装置では、吸気弁閉時期の変化によって吸入空気量が急増される。

【００１４】ここで、請求項３記載の装置では、上記第２の運転領域である高負荷領域では、常にピストン下死点からの上記吸気弁の閉時期のずれ角を上記第１の運転領域である低負荷領域でのピストン下死点からの上記吸気弁の閉時期のずれ角よりも大きく保つことにより、低空燃比が確保される。しかも、このようにして吸入空気量を抑えながらも、過給機による過給によって高負荷時に必要な出力トルクが確保される。

【００１５】特に、請求項４記載の装置では、上記第１の運転領域から第２の運転領域への移行時には吸気弁閉時期の遅れ角を増やすようにしているので、エンジン回転数が高まるにつれ、この吸気弁遅閉じに起因する吸入空気量の減少度合いは下がっていき、良好な高速性能が確保される。

【００１６】そして、請求項５記載の装置では、目標空燃比が排気ガス中の窒素酸化物濃度が最大となる空燃比よりも高い第１の運転領域と、目標空燃比が理論空燃比以下（すなわち排気ガス中の窒素酸化物濃度が最大となる空燃比よりも低い）第２の運転領域との間で移行する際、空燃比の切換が上述のように素早く行われることにより、窒素酸化物濃度の上昇が効果的に抑制される。

【００１７】

【実施例】本発明の一実施例を図面に基づいて説明する。なお、図１にはＶ型エンジンを示すが、本発明では吸入空気量制御の対象となるエンジンの種類を問わない。

【００１８】図１において、エンジン本体１は一対のバンク１ａ，１ｂを備え、各バンク１ａ，１ｂに複数の気筒２が設けられている。

【００１９】このエンジンの吸気通路３には、機械式過給機５が設けられ、この過給機５は、エンジン出力軸にベルト６等の伝動機構を介して連結されている。吸気通路３において過給機５の上流側には、エアクリーナ７、エアフローメータ８、スロットル弁９等が配設され、上記過給機５の下流側にはインタクーラ１０が設けられている。

【００２０】このインタクーラ１０の下流側で吸気通路３は第１吸気通路１１と第２吸気通路１２とに分岐し、さらにその下流側で各々独立吸気通路１３に分岐している。第１吸気通路１１から分岐した独立吸気通路１３は、バンク１ａの各気筒２に接続され、第２吸気通路１２から分岐した独立吸気通路１３は、バンク１ｂ側の各気筒２に接続されている。各独立吸気通路１３の下流端は各気筒２の燃焼室に開口する吸気ポート１４とされ、図例では各気筒２について２つの吸気ポート１４がそれぞれ設けられている。また、各独立吸気通路１３には燃料を吸気ポート１４に向けて噴射するインジェクタ（図示せず）が設けられている。

【００２１】上記吸気ポート１４はそれぞれ吸気弁１５により開閉され、各吸気弁１５は動弁装置により駆動さ

れる。この動弁装置には、吸気弁閉時期を変化させるバルブタイミング可変手段（開弁時期可変手段）２０が設けられている。

【００２２】この実施例に示すバルブタイミング可変手段２０は、図２のようにカムプロフィールの異なる２種類のカム２１，２２を備え、吸気弁リフト特性を変更するものとなっている。具体的に、吸気弁用のカムシャフト２３には、図３に実線５１に示すようにピストン上死点（ＴＤＣ）直前で開弁してピストン下死点（ＢＤＣ）直後に閉弁する第１の吸気弁リフト特性を与える低負荷用カム２１と、同図実線５２に示すように開弁時期は第１の吸気弁リフト特性と同等で閉弁時期が第１の吸気弁リフト特性よりも遅い第２の吸気弁リフト特性を与える高負荷用カム２２とが配設されている。そして、各カム２１，２２に対応するロッカーアーム２４，２５や、これらの連結／分離を行う図略の連結部材等により、吸気弁１５を低負荷用カム２１で駆動する状態と高負荷用カム２２で駆動する状態とに切換える切換機構が構成されている。

【００２３】この切換機構は、油圧回路による油圧供給状態の切換によって切換作動するものである。この油圧供給切換は図１に示す電磁弁２６により行われ、この電磁弁２６の切換制御はマイクロコンピュータ等からなるＥＣＵ（コントロールユニット；開弁期間制御手段）４０によって行われる。このＥＣＵ４０は、上記エアフローメータ８の出力する吸入空気量検出信号、エンジン回転数センサ４１の出力するエンジン回転数検出信号、スロットル開度センサ４２の出力するスロットル開度検出信号等を受け、これらの信号に基づいてエンジンの運転状態を分析し、その結果に基づいて電磁弁２６に制御信号を出力するように構成されている。

【００２４】具体的に、このＥＣＵ４０は次のような制御動作を行う。

Ａ）図３に示すようにエンジン負荷が一定以下の低負荷領域では、低負荷用カム２１による動弁状態を選択するように電磁弁２６に制御信号を出力するとともに、目標空燃比を理論空燃比よりも大きな空燃比（すなわち空気過剰率λが１を超える空燃比）とし、この目標空燃比に実際の空燃比を近付けるように図略のインジェクタによる燃料噴射量を制御する。

Ｂ）上記低負荷領域よりもエンジン負荷の高い高負荷領域では、高負荷用カム２２による動弁状態を選択するように電磁弁２６に制御信号を出力するとともに、目標空燃比を理論空燃比以下の空燃比（すなわち空気過剰率λが１以下の空燃比）とし、この目標空燃比に実際の空燃比を近付けるように図略のインジェクタによる燃料噴射量を制御する。

【００２５】ここで、上記低負荷領域における目標空燃比は、排気ガス中のＮＯｘ濃度が最大となる空燃比（前記図６の例では約１６；以下、便宜上ＮＯｘ最大空燃比と称する。）よりも十分高い空燃比が設定されている。

【００２６】一方、上記各気筒２の燃焼室内には図略の排気ポートが開口し、各排気ポートが図略の排気マニホールドを介して排気通路２８に接続されており、この排気通路２８の途中に排ガス浄化用の三元触媒３０が設けられている。

【００２７】次に、この装置の作用を説明する。

【００２８】まず、現在の運転状態が上記低負荷領域内の例えばＡ点にある場合には、吸気弁１５の動弁状態として、低負荷用カム２１による駆動状態、すなわちＴＤＣ直前で吸気弁１５が開弁され、ＢＤＣ直後に吸気弁１５が閉弁される状態が選択される（図４実線５１）。このような動弁状態での実際の吸入空気量がエアフローメータ８で検出され、この検出吸入空気量に基づき、実際の空燃比を理論空燃比よりも大きな目標空燃比に近付けるようにＥＣＵ４０による燃料噴射制御が実行される。ここで、上記目標空燃比には、ＮＯｘ最大空燃比よりも十分高い空燃比が設定されているので、このような空燃比制御によりＮＯｘの発生が抑制される。

【００２９】次に、エンジンの運転状態が上記Ａ点（図３）から上記高負荷領域内の例えばＢ点に移行すると、高負荷用カム２２による駆動状態、すなわち吸気弁１５の閉弁時期がさらに遅延された状態に切換えられる（図３実線５１）。このような吸気弁１５のいわゆる遅閉じにより、燃焼室内に吸入される空気の一部が吸気ポート１４側に吹き返されて最終的な吸入空気量が急減する。これにより、空燃比も瞬時に変化する。その後、実際の吸入空気量がエアフローメータ８で検出され、この検出吸入空気量に基づき、実際の空燃比を理論空燃比よりも小さな目標空燃比に近付けるようにＥＣＵ４０による燃料噴射制御が実行される。

【００３０】ここでの目標空燃比は理論空燃比以下であるため、三元触媒３０によって十分浄化され、しかも、上記吸入空気量の急減の際、実際の空燃比も上記理論空燃比近傍まで一気に下げられる（すなわち上記ＮＯｘ最大空燃比を飛び越して変化する）ため、空燃比切換時及び切換後の双方においてＮＯｘの抑制効果が維持される。

【００３１】なお、これとは逆に、エンジンの運転状態が高負荷領域から低負荷領域に移行する場合には、吸気弁１５の動弁状態が低負荷用カム２１による駆動状態に戻され、これにより吸入空気量が急増される。これにより実際の空燃比も迅速に高められ、低負荷領域での目標空燃比に近付けられる。

【００３２】以上のように、この装置では、低負荷領域から高負荷領域への移行時、あるいは高負荷領域から低負荷領域への移行時に、吸気弁１５の閉時期を変えることによって吸入空気量を急減もしくは急増するようにしたものであるので、空燃比を素早く増減することができる。従って、大きなトルクショックを発生させることな

くNOxの発生を十分に抑制しながら運転状態の切換を行うことができる。さらに、上記吸入空気量の増減を、燃焼室に極めて近い吸気弁15の閉時期の変化により行っているので、燃焼室から離れたスロットル弁9の開度変化やスロットル弁9のバイパス通路の開閉によって吸入空気量を変化させる場合よりも数段高い応答性を得ることができる。

【0033】また、高負荷領域への移行後は、吸気弁閉時期の遅延を続行しながらも、過給機5による過給によって高負荷時に必要な出力トルクを確保することができる。なお、この過給機5についてはその種類を問わず、ターボ過給機を利用するようにしてもよい。

【0034】本発明は、以上の実施例に限定されるものでなく、例として次のような態様をとることも可能である。

【0035】(1) 上記実施例では、低負荷領域において通常タイミング（図4実線51に示すタイミング）とし、高負荷領域で低負荷領域よりも遅れ角を増やすことにより吸入空気量を急減させているが、逆に、高負荷領域で低負荷領域よりも吸気弁閉時期を進ませる、例えばピストン下死点よりも進ませる（いわゆる早閉じ）ことによっても吸入空気量を急減させることが可能である。ただし、上記実施例に示すように高負荷領域で遅れ角を増やす制御を行えば、エンジン回転数の上昇に伴って吸気弁閉時期の遅れによる吸入空気量の低減度合いが下がっていくので、吸気弁15をいわゆる遅閉じにしながらも良好な高速性能を確保することができる。

【0036】(2) 本発明は、開弁期間の変化によって吸入空気量を増減するものであれば良く、例えば燃焼室内に第1吸気ポート及び第2吸気ポートを開口させ、吸気弁の第1吸気ポートにおける吸気弁の開弁特性を図5実線61に示すような通常の特性とし、第2吸気ポートにおける吸気弁の開弁特性を同図破線62に示すように上記通常特性から位相を遅らせた特性とするとともに、低負荷領域では第2吸気ポートにおける吸気弁を弁停止機構によって常閉状態にし、低負荷領域から高負荷領域への移行時には弁停止機構による弁停止を解除して第2吸気ポートも開けば、いわゆる遅閉じと同等の作用が得られ、吸入空気量の急減を果たすことができる。なお、この高負荷領域への移行後は、バルブタイミング可変機構によって第2吸気ポートにおける開弁特性（図5破線62）を上記通常特性（同図実線61）に徐々に近付けていくことにより、エンジン出力を高めることが可能である。ここで、上記バルブタイミング可変機構としては、カムプーリに対するカムシャフトの回転位相を変化させる周知の機構が適用可能である。

【0037】(3) 上記実施例では、吸気弁15の開弁期間を変えることによって吸入空気量の制御を行うようにしているが、同様に、上記排気ポートを開閉する排気弁の開弁期間を変えることによっても残留ガス量や吸気吹

き抜け量の変化によって吸入空気量の制御が可能である。

【0038】(4) 上記実施例では、エンジン負荷に基づいて運転領域を2つに分けたものを示したが、本発明はこれに限らず、予め設定された第1の運転領域で目標空燃比を理論空燃比よりも高い空燃比とし、これと異なる第2の運転領域で目標空燃比を理論空燃比以下の空燃比とした制御が行われるエンジンに広く適用できるものである。

【0039】

【発明の効果】以上のように本発明は、目標空燃比が理論空燃比よりも大きい第1の運転領域から目標空燃比が理論空燃比以下の第2の運転領域への移行時には吸入空気量を減らし、上記第2の運転領域から第1の運転領域への移行時には吸入空気量を増加させるべく、燃焼室に極めて近い吸気弁、排気弁の少なくとも一方の開弁期間を変えるようにしたものであるので、燃料噴射量を急激に増減することなく、すなわち大きなトルクショックを発生させることなく、高い応答性で実際の空燃比を素早く変化させることができる効果がある。

【0040】より具体的に、請求項2記載の装置では、両運転領域間での移行時に上記吸気弁の閉時期を変えるだけで、吸入空気量及び空燃比の素早い切換を実現することができる効果がある。

【0041】さらに、請求項3記載の装置では、上記第2の運転領域である高負荷領域では、常にピストン下死点からの上記吸気弁の閉時期のずれ角を上記第1の運転領域である低負荷領域でのピストン下死点からの上記吸気弁の閉時期のずれ角よりも大きく保つことにより、吸入空気量を抑えて低空燃比を維持する一方、このように吸気弁閉時期をピストン下死点から大きくずらしながらも過給機による過給によって高負荷時に必要な出力トルクを確保することができる効果がある。

【0042】特に、請求項4記載の装置では、上記第1の運転領域から第2の運転領域への移行時には吸気弁閉時期の遅れ角を増やすようにしているので、エンジン回転数が高まるにつれて上記吸気弁遅閉じに起因する吸入空気量の減少度合いが下がっていくことにより、良好な加速性を確保することができる効果がある。

【0043】そして、請求項5記載の装置では、目標空燃比が排気ガス中の窒素酸化物濃度が最大となる空燃比よりも高い第1の運転領域と、目標空燃比が理論空燃比以下（すなわち排気ガス中の窒素酸化物濃度が最大となる空燃比よりも低い）第2の運転領域との間で移行する際、空燃比の切換を上述のように素早く行うことにより、この移行時の窒素酸化物濃度の上昇を確実に抑制することができる効果がある。

【図面の簡単な説明】

【図1】本発明の一実施例におけるエンジンの吸気系を示す平面図である。

【図２】上記エンジンに設けられるバルブタイミング可変手段の平面図である。

【図３】上記エンジンにおいて空燃比制御用に設定される各運転領域を示すグラフである。

【図４】上記エンジンにおける吸気弁の動弁特性を示す図である。

【図５】上記動弁特性の変形例を示す図である。

【図６】空燃比と排気ガス中のＮＯｘ濃度との関係を示すグラフである。

【符号の説明】

1　エンジン本体

2　気筒

3　吸気通路

5　過給機

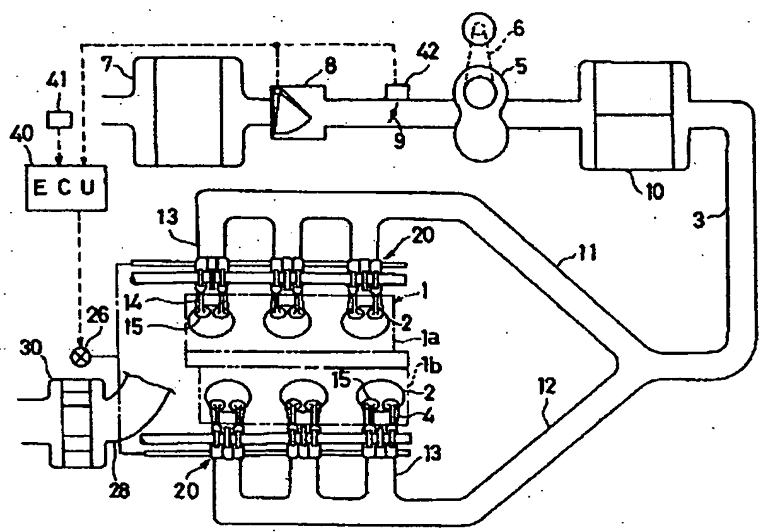
１４　吸気ポート

１５　吸気弁

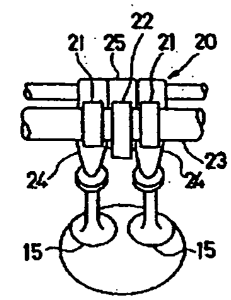
２０　バルブタイミング可変手段（開弁期間可変手段）

４０　ＥＣＵ（開弁期間制御手段）

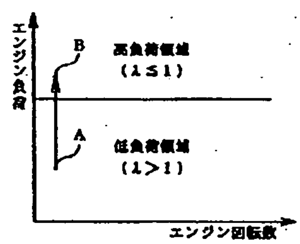
【図１】



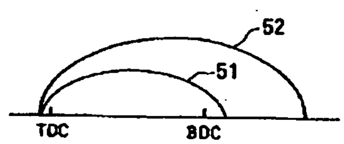
【図２】



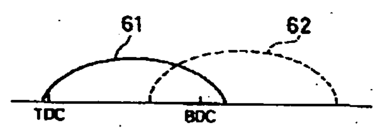
【図３】



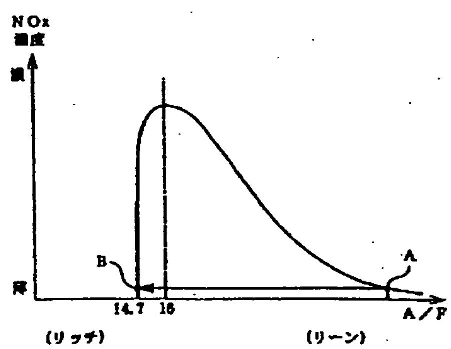
【図４】



【図５】



【図６】



JAPANESE LAID-OPEN PATENT APPLICATION

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(71) Applicant	000003137 Mazda Motor Corporation 3-1 **Arachi** Fuchu-cho Aki-gun Hiroshima-ken
(72) Inventor	Mitsuo Hitomi C/O Mazda Motor Corporation 3-1 **Arachi** Fuchu-cho Aki-gun Hiroshima-ken
(72) Inventor	Noriyuki Iwata C/O Mazda Motor Corporation 3-1 **Arachi** Fuchu-cho Aki-gun Hiroshima-ken
(74) Agent	Etsuji Kotani, Attorney (and 3 others)

(54) Title of the Invention

INTAKE AIR FLOW CONTROLLER OF AN ENGINE

(57) Abstract

Purpose: To quickly vary an air-fuel ratio of an engine with high responsiveness without generating a large torque shock.

Constitution: A valve timing variable means 20 varies the closing timing of an air intake valve 15. The ECU 40 controls activation of the valve timing variable means 20 so that the air-fuel ratio of an engine is controlled by having a target air-fuel ratio larger than a theoretical air-fuel ratio in a low load range, and by having a target air-fuel ratio less than a theoretical air-fuel ratio in a high load range; and also intake air flow can be decreased by increasing the delay angle from the piston bottom dead center of the air intake valve closing timing at the time of transferring from the low load range to the high load range, and an intake air flow can be increased by decreasing the delay angle from the piston bottom dead center of the air intake valve closing timing at the time of transferring from the high load range to the low load range.

Scope of Claims

Claim 1

An intake air flow controller of an engine in which the actual air-fuel ratio is controlled by making an air-fuel ratio in a preset first operational range in which a target air-fuel ratio is larger than a theoretical air-fuel ratio, and by making an air-fuel ratio in a second operational range differing from the first operational range in which a target air-fuel ratio is less than a theoretical air-fuel ratio, comprising:
an opening valve timing variable means to vary the opening timing of at least one of air intake valves and exhaust valves of an engine; and an opening valve timing control means to activate said opening valve timing variable means for decreasing intake air flow at the time of transferring from the first operational range to the second operational range, and increasing intake air flow at the time of transferring from the second operational range to the first operational range.

Claim 2

The intake air flow controller of an engine according to claim 1, wherein the opening valve variable means is to vary the closing timing of the air intake valve, and the opening valve control means activates the opening valve timing variable means to close the air intake valve at a timing by decreasing the intake air flow at the time of transferring the first operational range to the second operational range, and increasing the intake air flow at the time of transferring from the second operational range to the first operational range.

Claim 3

The intake air flow controller of an engine according to claim 2 further comprises a supercharger, wherein the opening valve timing control means is constructed so that the opening valve timing variable means can be activated to maintain a disparity angle at a time of closing the air intake valve from the piston bottom dead center in the second operational range that is larger than the disparity

angle at a time of closing the air intake valve from the piston bottom dead center in the first operational range while the first operational range is the low load range in which engine load is less than constant, and the second operational range is the high load range in which engine load is higher than the first operational range.

Claim 4

The intake air flow controller of an engine according to claim 3, wherein the opening valve timing control means activates the opening valve timing variable means so as to increase the delay angle at the time of closing the air intake valve from the piston bottom dead center at the time of transferring from the first operational range to the second operational range, and decrease the delay angle at the time of closing the air intake valve from the piston bottom dead center at the time of transferring from the second operational range to the first operational range.

Claim 5

The intake air flow controller of an engine according to any of claims 1 through 4, wherein a target air-fuel ratio in the first operational range is higher than the air-fuel ratio in which the nitrogen oxide level in the exhaust gas is at the maximum.

Detailed Description of the Invention

0001

Industrial Applications

The present invention relates to a device to control intake air flow in an engine in which the air-fuel ratio is controlled according to the state of operation.

0002

Prior Art

Reduction of the nitrogen oxide levels (NOx) in engine exhaust gas has been a major challenge in recent years, and it is commonly known that there is a relationship, as shown in FIG. 6, between the NOx level and the actual air-fuel ratio A/F. According to this relationship, because the NOx level reaches a peak when the air-fuel ratio A/F is at a constant value (about 16), the operation should be controlled by avoiding the above air-fuel ratio as much as possible in order to reduce the NOx level. For instance, an increase in NOx level is avoidable by trying to avoid using an air-fuel ratio near A/F = 16 for not even a moment by dropping the air-fuel ratio A/F from point A to point B at once and not dropping gradually when transferring a fuel lean combustion state (point A) to a fuel rich combustion state (point B) in accordance with the varying state of operation of the engine. Conversely, the air-fuel ratio A/F may be lean at once when transferring from point B to point A.

0003

Adjusting the intake air flow has been common as the means to control the air-fuel ratio; however, there are some disadvantages to generating delay in varying air flow in order to increase or decrease the air-fuel ratio instantly in the above manner, and this causes a time lag between the air-fuel ratio and ignition timing and this leads to a large torque shock.

0004

Accordingly, Japanese Laid-Open Patent Publication H04-265437 has proposed a device to increase the actual air-fuel ratio instantly by increasing intake air flow through opening the bypass passage of the throttle valve when the target air-fuel ratio is switched to the lean side.

0005

Problems Overcome by the Invention

The bypass and the air intake passage from the bypass passage to the combustion chamber of each cylinder in the above Japanese Laid-Open Patent Publication are comparatively long and have a large volume. Subsequently, there is considerable response delay from the time of initiating an open/close switch of the bypass passage until actual intake air flow is increased, and there is a difficulty in controlling the air-fuel ratio at the appropriate timing, plus there is the trouble in which the change of air-fuel ratio in this response delay time becomes sluggish and an air-fuel ratio having a high NOx level passes through. This disadvantage is generated in the same manner even when the intake air flow is increased or decreased by the temperature adjustment of the throttle valve.

0006

The object of the present invention, giving consideration to such circumstances, is to provide an intake air flow controller of an engine that enables the actual air-fuel ratio to quickly vary with high response while avoiding torque shock due to an abrupt change in the amount of fuel consumption.

0007

Problem Resolution Means

In order to resolve the challenge described above, the present invention of an engine in which the actual air-fuel ratio is controlled by making the air-fuel ratio in a preset first operational range in which a target air-fuel ratio is larger than a theoretical air-fuel ratio, and by making an air-fuel ratio in a second operational range differing from the first operational range in which a target air-fuel ratio is less than a theoretical air-fuel ratio, comprises an opening valve timing variable means to vary the opening timing of at least one of air intake valves and exhaust valves of the engine; and an opening valve timing control means to activate the opening valve timing variable means for decreasing intake air flow at the time of transferring from the first operational range to the second operational range, and increasing intake air flow at the time of the transferring from the

second operational range to the first operational range (claim 1).

0008

More specifically, the opening valve variable means is to vary a closing timing of the air intake valve, and preferably, the opening valve control means activates the opening valve timing variable means to close the air intake valve at a timing by decreasing the intake air flow at the time of transferring the first operational range to the second operational range, and increase the intake air flow at the time of transferring from the second operational range to the first operational range (claim 2).

0009

A supercharger is further provided, wherein an excellent efficacy as described hereinafter can be obtained by constructing the opening valve timing control means so that the opening valve timing variable mans can be activated to maintain a disparity angle at a time of closing the air intake valve from the piston bottom dead center in the second operational range to be larger than the disparity angle at a time of closing the air intake valve from the piston bottom dead center in the first operational range while the first operational range is in a low load range in which engine load is less than constant, and the second operational range is in the high load range in which engine load is higher than the first operational range (claim 3).

0010

Here, preferably, the opening valve timing control means activates the opening valve timing variable means so as to increase the delay angle at the time of closing the air intake valve from the piston bottom dead center at the time of transferring from the first operational range to the second operational range, and decrease the delay angle at a time of closing the air intake valve from the piston bottom dead center at the time of transferring from the second operational range to the first operational range (claim 4).

0011

Each device described above is particularly effective when a target air-fuel ratio in the first operational range is higher than the air-fuel ratio in which the nitrogen oxide level in exhaust gas are at the maximum (claim 5).

0012

Operation

According to the above device, the air-fuel ratio is possible to be switched instantly by decreasing the intake air flow at the time of transferring from the first operational range to the second operational range, and increasing the intake air flow at the time of transferring from the second operational range to the first operational range. In other words, intake air flow and the air-fuel ratio can be varied instantly, and the control response can be significantly improved in comparison to controlling the intake air flow by opening or closing the throttle valve apart from the combustion chamber and its bypass passage because the increasing or decreasing of intake air flow is performed by controlling the opening valve timing of the air intake valve and the exhaust valve which opens or closes the combustion chamber.

0013

More specifically, intake air flow is increased rapidly by varying of the air intake valve closing timing in a device described in Claim 2.

0014

In a device described in Claim 3, a low air-fuel ratio can be secured in the high load range that is the second operational range, by maintaining at all times a disparity angle at the time of

closing the air intake valve from the piston bottom dead center that is larger than the disparity angle at the time of closing of the air intake valve from the piston bottom dead center in the low load range that is the first operational range. Further, the output torque that is necessary at the time of high load is secured by supercharging by a supercharger while the intake air flow is suppressed in such manner.

0015

In a device described in Claim 4, a delay angle at the time of closing the air intake valve when transferring from the first operation to the second operational range is designed to be increased, so the decreasing level of intake air flow caused by a delay in closing the air intake valve is lowered as increasing the engine revolutions, and a favorable high-speed performance can be assured.

0016

In a device described in Claim 5, the increasing of nitrogen oxide level can be suppressed effectively by switching the air-fuel ratio instantly as described above when transferring between the first operational range in which a target air-fuel ratio is higher than the air-fuel ratio where the nitrogen oxide level in exhaust gas is at the maximum, and the second operational range in which a target air-fuel ratio is less than a theoretical air-fuel ratio (in other words, less than the air-fuel ratio where the nitrogen oxide level in exhaust gas is at the maximum).

Embodiment

0017

A preferred embodiment of the present invention is explained hereafter with reference to the drawings. In addition, a V-type engine is shown in FIG. 1; however, the present invention has no distinction of the types of engine that can be a subject of the intake air flow control.

0018

In FIG. 1, a base engine 1 comprises a pair of banks 1a and 1b, and a plurality of cylinders 2 is provided respectively in each bank 1a and 1b.

0019

A mechanical supercharger 5 is provided in an air intake passage 3, and this supercharger is connected to the engine output axis through the transmission mechanism such as a belt 6 or the like. In the air intake passage 3, an air cleaner 7, an air flow meter 8, a throttle valve 9, or the like are arranged at the upstream side of the supercharger 5, and an intercooler 10 is provided at the downstream side of the supercharger 5.

0020

The air intake passage 3 is forked to be a first air intake passage 11 and a second air intake passage 12 at the downstream side of the intercooler 10, and these are further divided into an independent air intake passage 13 respectively further downstream. An independent air intake passage 13 divided from the first air intake passage 11 is connected to each cylinder respectively of the bank 1a, and an independent air intake passage 13 divided from the second air intake passage 12 is connected to each cylinder of the bank 1b side respectively. The downstream end of each of independent air intake passages 13 is an air intake port 14 to open to the combustion chamber of each cylinder 2, and two air intake ports 14 are provided respectively regarding each cylinder 2 in the drawing. Further, an injector (not illustrated) to inject fuel toward the air intake port 14 is provided in each independent air intake passage 13.

0021

The air intake ports 14 are opened and closed by the air intake valves 15 respectively, and

each air intake valve 15 is driven by a valve operating device. A valve timing variable means (opening valve timing variable means) 20 to vary the air intake valve closing timing is provided at the valve operating device.

0022

The valve timing variable means 20 shown in the present embodiment comprises the cams 21 and 22 having two different types of cam profiles shown in FIG. 2, and which changes the air intake valve lifting property. More specifically, the cam 21 for the low load to give the first air intake valve lifting property which opens the valve at just before the piston top dead center (TDC) and closes the valve right after the piston bottom dead center (BDC) as shown with a solid line 51 in FIG. 3, and the cam 22 for the high load to give the second air intake valve lifting property where the opening valve timing is the same with the first air intake valve lifting property and the closing valve timing is delayed that is later than the first air intake valve lifting property as shown with a solid line 51 in the same drawing, are provided in a cam shaft 23. A switching mechanism is constructed to switch the air intake valve 15 between the state driven by the low load cam 21 and the state driven by the high load cam 22 by the rocker arms 24 and 25 which correspond to the cams 21 and 22 respectively, and a connecting member or the like, not illustrated, to performs the connection or separation.

0023

The switching mechanism is operated by switching the state of the hydraulic pressure supply by the hydraulic circuit. This hydraulic pressure supply switch is performed by an electromagnetic valve 26 shown in FIG. 1, and the switch control of this electromagnetic valve 26 is performed by ECU (the control unit; the opening valve timing control means) 40 consisting of a microcomputer or the like. This ECU 40 is constructed to receive the intake air flow detecting signal output by the air flow meter 8, the engine speed detecting signal output by the engine speed sensor 41, the throttle opening level detecting signal output by the throttle opening sensor 42, or the like, and the engine operational state is analyzed based on these signals, and then, the control signal is output to the

electromagnetic valve 26 based on the result.

0024

More specifically, this ECU 30 performs the following control operations:
A) To control the fuel injection amount by an injector, not illustrated, so as to bring the actual air-fuel ratio closer to the target air-fuel ratio while the control signal is output to the electromagnetic valve 26 to select the valve operating state by the low load cam 21, and the target air-fuel ratio is larger than the theoretical air-fuel ratio (in other words, the air-fuel ratio in which the air excess ratio λ exceeds 1) in the low load range in which the engine load is less than constant as shown in FIG. 3.
B) To control the fuel injection level by the injector, not illustrated, so as to bring the actual air-fuel ratio closer to the target air-fuel ratio while the control signal is output to the electromagnetic valve 26 to select the valve operating state by the high load cam 22, and the target air-fuel ratio is less than the theoretical air-fuel ratio (in other words, the air-fuel ratio in which the air excess ratio λ is 1 or less) in the high load range in which the engine load is higher than the low load range.

0025

Here, the target air-fuel ratio in the low load range is set to a sufficiently higher air-fuel ratio than the air-fuel ratio in which the NOx level is at the maximum in the exhaust gas (about 16 in the example given above in FIG. 6: hereinafter referred to as the NOx maximum air-fuel ratio).

0026

In contrast, an exhaust port, not illustrated, is opened in the combustion chamber of each cylinder 2, and each exhaust port is connected to an exhaust air passage 28 through the exhaust manifold, not illustrated, and a three-way catalyst 30 for exhaust gas purification is provided at mid-way through the exhaust air passage 28.

0027

The operation of this device is explained hereinafter.

0028

First, when the current operational status is, for instance, at the A point in the low load range, the driven state by the low load cam 21 is selected, in other words, the state where the air intake valve 15 is opened right before the TDC and the air intake valve 15 is closed right after the BDC, is selected (the solid line 51 in FIG. 4). The actual intake air flow in such valve operation state is detected by the air flow meter 8, and the fuel injection control is performed by the ECU 40 so as to bring the actual air-fuel ratio close to the target air-fuel ratio that is larger than the theoretical air-fuel ratio based on the detected intake air level. Because the target air-fuel ratio is set to a sufficiently higher air-fuel ratio than the NOx maximum air-fuel ratio here, the NOx generation can be suppressed by such air-fuel ratio control.

0029

Next, when an engine operation state transfers from the A point (FIG. 3) to, for instance, the B point in the high load range, the driven state by the high load cam 22 that is the closing timing of the air intake valve 15 is switched to a further delayed state (the solid line 51 in FIG. 3). The ultimate intake air flow is sharply decreased by splitting a portion of the air that is taken into the combustion chamber to the air intake port 14 side by a delayed closing of the air intake valve 15. By so doing, the air-fuel ratio is also changed instantly. Subsequently, the actual intake air flow is detected by the air flow meter 8, and the fuel injection control is executed by the ECU 40 to bring the actual air-fuel ratio closer to the target air-fuel ratio that is smaller than the theoretical air-fuel ratio based on the detected intake air flow.

0030

The target air-fuel ratio here is less than the theoretical air-fuel ratio, and accordingly, the

efficient purification is achieved by the three-way catalyst 30, and the suppression effect of the NOx can be maintained in both times of air-fuel ratio switch timing and after the switch due to the instant decreasing of the actual air-fuel ratio to near the theoretical air-fuel ratio as well (in other words, a change is made by skipping over the NOx maximum air-fuel ratio).

0031

In addition, contrary to this, when the engine operation state transfers from the high load range to the low load range, the valve operation state of the air intake valve 15 is switched back to a driven state by the low load cam 21, and this sharply increases the intake air flow. By so doing, the actual air-fuel ratio is increased swiftly, and enables getting closer to the target air-fuel ratio in the low load range.

0032

As stated above, this device is constructed to sharply increase or decrease the intake air flow by varying the closing timing of the air intake valve 15 at the time of transferring from the low load range to the high load range, or from high load range to the low load range, so the air-fuel ratio can be increased or decreased instantly. Therefore, switching the operational state can be performed while the NOx generation is suppressed sufficiently without generating a large torque shock. Further, because increasing and decreasing of the intake air flow is performed by varying the close timing of the air intake valve 15 which is extremely close to the combustion chamber, a significantly higher response can be obtained over varying the intake air flow by opening or closing the bypass passage of the throttle valve 9 or varying the opening of the throttle valve 9 apart from the combustion chamber.

0033

Further, the output torque that is necessary at the time of high load can be secured through supercharging by the supercharger 5 while preceding the delay of the air intake valve closing timing

after transferring to the high load range. In addition, there is no distinction in type regarding the supercharger 5, and a turbo supercharger may be used.

0034

The present invention is not limited to the above embodiment, and the following Embodiments are also possible as examples.

0035

(1) Intake air flow is sharply decreased by increasing the delay angle in the high load range more than the low load range with the low load range as the normal timing (the timing shown with the solid line 51 in FIG. 4) in the above preferred embodiment; conversely, intake air flow is also possible to be sharply decreased by advancing the air intake valve closing timing in the high load range earlier than the low load range, for instance, by advancing from the piston bottom dead center (namely, early closing). However, the extent of decrease in the intake air flow is lowered by the delay in the air intake valve closing timing with an increase in the engine revolution speed by controlling to increase the delay angle in the high load range as shown in the above embodiment, so a favorable high speed performance can be ensured while having a so-called delayed closing of the air intake valve 15.

0036

(2) The present invention requires that the air intake air flow is increased or deceased by varying the opening valve timing; for instance, the intake air flow can be sharply decreased by having the air intake valve in the second air intake port in the low load range to be in the normally closed state by the valve suspension mechanism, and opening the second air intake port also by releasing the valve suspension by the valve suspension mechanism at the time of transferring from the low load range to the high load range so that the same affect with the delay closing can be obtained while the first intake port and the second intake port are opened in the combustion

chamber, and the opening valve property of air intake valve in the first air intake port of the air intake valve is the normal property as shown in FIG. 5 with the solid line 61, and the opening valve property of the air intake valve in the second air intake port is the property to delay a phase from the normal property as shown with the dashed line 62 in the same drawing. In addition, the engine output can be increased by bringing the opening valve property (the dashed line 62 in FIG. 5) in the second air intake port by the valve timing variable mechanism closer to the normal property (the solid line 61 in the same drawing) gradually after transferring to the high load range. Here, a widely known mechanism to vary revolution phase of the cam shaft to the cam pulley may be applicable.

0037

(3) Intake air flow control is performed by varying the opening valve timing of the air intake valve 15 in the above embodiment; however, intake air flow control is also possible in the same manner by the air intake blowing amount and the residual gas level by means of varying the opening valve timing of the exhaust air valve to open and close the exhaust port.

0038

(4) The above embodiment shows that the operational range is divided into two based on the engine load; however, the present invention is not limited to this, but widely applicable to the engines that control by having the target air-fuel ratio in the preset first operational range to be higher than theoretical air-fuel ratio, and the target air-fuel ratio in the second operational range that is different from above to be lower than the theoretical air-fuel ratio.

0039

Effect of the Invention

The present invention as stated above has the effect to enable change in the actual air-fuel ratio instantly with a high response without increasing or decreasing the fuel injection level sharply

and without generating a large torque shock because intake air flow is decreased at the time of transferring from the first operational range in which the target air-fuel ratio is larger than the theoretical air-fuel ratio to the second operational range in which the target air-fuel ratio is less than the theoretical air-fuel ratio, and intake air flow is increased at the time of transferring from the second operational range to the first operational range by varying the opening valve timing of at least one of the air intake valve or exhaust valve that is extremely close to the combustion chamber.

0040

More specifically, the device according to claim 2 has the effect in which the instant switch of intake air flow and air-fuel ratio can be realized by just simply varying the closing timing of the air intake valve at the time of transferring between both operational ranges.

0041

Further, the device according to claim 3 has the effect for the ability to ensure the output torque that is necessary for the high load range by supercharging through the supercharger while the intake valve close timing is staggered largely from the piston bottom dead center whereas maintaining the low air-fuel ratio by suppressing the intake air flow by always keeping the disparity angle at the time of closing of the air intake valve from the piston bottom dead center in the high load range that is the second operational range, to be larger than the disparity angle at the time of closing of the air intake valve from the piston bottom dead center in the low load range that is the first operational range.

0042

The device according to claim 4 particularly has the effect for the ability to ensure a favorable acceleration performance by lowering the extent of decrease in the intake air flow caused by the air intake valve delayed closing as the engine speed gets faster because the delay angle of the air intake valve closing timing is designed to be increased at the time of transferring from the first

operational range to the second operational range.

0043

Moreover, the device according to claim 5 has the effect for the ability to suppress the nitrogen oxide level rising at the time of transferring by switching the air-fuel ratio instantly as stated above when transferring between the first operation range in which the target air-fuel ratio is higher than the air-fuel ratio where the nitrogen oxide level in the exhaust gas is at the maximum and the second operation range in which the target air-fuel ratio is less than the theoretical air-fuel ratio (in other words, less than the air-fuel ratio in which the nitrogen oxide level in the exhaust gas is at maximum).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plane view showing an air intake system of an engine in an embodiment of the present invention.

FIG. 2 is a plane view of a valve timing variable means provided in the above engine.

FIG. 3 is a graph showing each operation range specified for the air-fuel ratio control in the above engine.

FIG. 4 is a drawing showing a valve operating property of an air intake valve in the above engine.

FIG. 5 is a drawing showing a modified example of the above valve operating property.

FIG. 6 is a graph showing the relationship between the air-fuel ratio and the NOx level in the exhaust gas.

Explanation of Referenced Numerals

1	Base engine
2	Cylinder
3	Air intake passage
5	Supercharger
14	Air intake port
15	Air intake valve

20 Valve timing variable means (Opening valve timing variable means)
40 ECU (opening valve timing control means)

FIG. 3

Engine load [vertical axis]
Engine speed [horizontal axis]

B High load range ($\lambda \leq 1$)
A Low load range ($\lambda > 1$)

FIG. 6

NOx level [vertical axis]
Thick [top]
Thin [bottom]
(Rich) [Towards the left of the horizontal axis]
(Lean) [Towards the right side of the horizontal axis]